

Relationships Between Alcohol Policies and Infant
Morbidity and Injuries

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Introduction: Previous research has found that policies specifically focused on pregnant people's alcohol use are largely ineffective. Therefore, the purpose of this study is to analyze the relationships between general population policies regulating alcohol physical availability and outcomes related to pregnant people's alcohol use, specifically infant morbidity and injuries.

Methods: Outcome data were obtained from Merative MarketScan, a longitudinal commercial insurance claims data set. Policy data were obtained from the National Institute on Alcohol Abuse and Alcoholism's Alcohol Policy Information System, the National Alcohol Beverage Control Association, and Liquor Handbooks and merged using policies in effect during the estimated year of conception. Relationships between state-level policies regulating sites, days/hours, and government monopoly of liquor sales and infant morbidity and injuries were examined. Analyses used logistic regression with individual controls, fixed effects for state and year, state-specific time trends, and SEs clustered by state. The study analysis was conducted from 2021 to 2023.

Results: The analytic sample included 1,432,979 infant-birthing person pairs, specifically people aged 25–50 years who gave birth to a singleton between 2006 and 2019. A total of 3.1% of infants had a morbidity and 2.1% of infants had an injury. State government monopoly on liquor sales was associated with reduced odds of infant morbidity and injuries, whereas gas station liquor sales were associated with increased odds of infant morbidity and injuries. Allowing liquor sales after 10PM was associated with increased odds for infant injuries. No effect was found for allowing liquor sales in grocery stores or on Sundays.

Conclusions: Findings suggest that limiting alcohol availability for the general population may help reduce adverse infant outcomes related to pregnant people's alcohol use.

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INTRODUCTION

Pregnant people's use of alcohol is linked to a range of adverse child health and development outcomes.^{1,2} Reducing the harms related to pregnant people's alcohol use has been a public health priority since the 1980s,^{1,3–5} and states have adopted a range of policies specifically targeting pregnant people's alcohol consumption.^{6,7} However, previous research has found that many of these policies are ineffective and, in some cases, may contribute to worse outcomes.^{8–11} These policies relate to adverse outcomes for infants, including low birth weight and preterm birth,^{9,12} costing hundreds of millions of dollars annually,¹³ as well as

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increased infant morbidities related to alcohol use during pregnancy and increased infant injuries consistent with maltreatment.¹⁰ Mechanisms through which pregnancy-specific policies relate to adverse outcomes may include pregnant people avoiding care owing to fear of being reported, mistrust of government warnings, and limited resources for implementation of treatment-focused policies.^{14–16}

On the other hand, research has found that general population or universal alcohol policies—especially policies that reduce alcohol availability—are effective in reducing harms from alcohol consumption.^{17,18} Categories of availability include physical (e.g., types of stores that can sell alcohol), economic (e.g., taxes), and legal (e.g., minimum legal drinking age).¹⁹ Previous work has found that general population policies limiting alcohol physical availability are particularly effective in reducing alcohol consumption and related harms.²⁰ Physical availability policies restrict how, when, and where retailers can sell alcohol.^{19,20} This category includes a broad range of policy interventions, and there is substantial variability across states.²¹ For example, state policies can focus on site, days/hours, or government monopoly control of alcohol sales.^{19,20}

A large literature looks at the relationships between physical availability policies, alcohol consumption, and related harms. Systematic reviews have found that policies that increase the physical availability of alcohol are associated with increased consumption and alcohol-related harms (such as crime, injuries, and hospitalizations).^{22,23} For example, evidence suggests that increasing hours of sale,^{24–26} allowing alcohol sales on Sunday,^{27–30} and modifying and/or eliminating government monopoly control of retail alcohol sales in favor of privatization^{31–33} relate to increased consumption and alcohol-related harms. Research has also found that increased physical availability of alcohol in practice was associated with adverse child outcomes, such as higher rates of maltreatment^{34,35} and child homicide deaths,³⁶ although this has been less studied than other alcohol-related consequences.³⁷

There is less research on general population policies and outcomes related to pregnant people's alcohol use. Ostensibly, only two studies have been done, both in Sweden. Researchers found that making strong beer (>4.5% alcohol by volume) available in Sweden's supermarkets was associated with worse economic and educational outcomes of prenatally exposed children³⁸ but no statistically significant change in health-related outcomes.³⁹ Although not focused on pregnancy in particular, one U.S. study found that availability policies do relate to drinking among women of reproductive age—specifically, government monopoly control of retail

liquor sales was associated with fewer days of binge drinking, and policies allowing heavy beer sales at gas stations and liquor sales on Sunday were related to higher rates of heavy drinking.⁴⁰

Given that policies specifically aimed at reducing pregnant people's alcohol consumption and related harms are largely ineffective,^{6,8–11,14} it is important to understand whether alternate approaches, such as those focused on general population alcohol use, might be more relevant. This is especially important for outcomes that are often the focus of pregnancy-specific alcohol policies: infant morbidities related to pregnant people's alcohol consumption and infant injuries consistent with maltreatment. Therefore, this study examines the relationships between general population alcohol physical availability policies and outcomes related to pregnant people's alcohol use, specifically infant morbidities and injuries.

METHODS

Outcome data for this retrospective cohort study were obtained from the Merative MarketScan Commercial Claims and Encounters database, a commercially available health insurance claims database that contains claims for a sample of privately insured people in all 50 U.S. states and Washington, DC. Claims have been adjudicated for payment and were obtained directly from a convenience sample of health plans and large employers. Policy data were obtained from various sources, including the National Institute on Alcohol Abuse and Alcoholism's Alcohol Policy Information System,²¹ Liquor Handbooks,⁴¹ and the National Alcoholic Beverage Control Association.⁴²

Study Population

The study population included all reproductive-aged (12–50 years) female (as classified in the MarketScan database) beneficiaries who resided in a U.S. state or Washington, DC; gave birth to a singleton between 2006 and 2019 at least 280 days after a previous birth; had been continuously enrolled one year before and one year after delivery; and could be matched with an infant who was enrolled for one year after birth ($n=1,666,425$). Birthing people aged <25 years ($n=91,228$) were excluded because over 70% could not be matched with an infant, and those that were matched may differ from the broader group of birthing people aged <25 years. Births where the infant did not have a claim within the first month ($n=142,218$) were also excluded because data on key study outcomes were incomplete for this group. See previously published literature for a flow diagram reflecting these details on cohort creation.¹⁰ The final analytic sample included 1,432,979 infant-birthing person pairs.

Measures

Primary outcome measures were dichotomous variables for infant morbidities, specifically morbidities that previous literature⁴³ has identified as being related to alcohol use during pregnancy, and infant injuries, specifically injuries with positive predictive values >50% for maltreatment based on previous literature.⁴⁴ Secondary measures of healthcare utilization were also included as robustness checks, specifically dichotomous variables indicating two or more emergency department (ED) visits and two or more inpatient admissions. Outcome variables were measured from birth to one year and were constructed using the International Classification of Diseases, Ninth and Tenth Revision diagnosis codes. The specific diagnosis codes for the main outcomes are available in [Appendix Table 1](#) (available online).

State-level policies that regulate the physical availability of alcohol were operationalized as 5 dichotomous variables: site of sale (liquor sales allowed in grocery stores versus not allowed, liquor sales allowed in gas stations versus not allowed), day of sale (Sunday off-premise liquor sales allowed versus not allowed), hours of sale (after 10PM off-premise liquor sales allowed versus not allowed), and government monopoly (state government monopoly control of liquor retail sales versus not control). The focus was liquor sales because there was more variation across states and years for policies regulating liquor,²¹ and previous research has found that greater control of liquor sales effectively reduces alcohol consumption and related harms.^{45–47} Heavy beer policies were not included owing to the high overlap between state-level liquor and beer policies²¹ and because the few changes in beer policies during the study period happened in states with relatively small populations. Economic availability policies were not included in the current analysis because many tax data are only available for the subset of states without government monopolies. Legal availability policies (e.g., minimum legal drinking age policies) were not feasible to examine in this study, given that people aged <25 years were excluded. *Exposure to a policy* was defined as the policy being in effect in the birthing person's state of residence during the estimated year of conception.

Statistical Analysis

Multivariate logistic regression was used to analyze all policy indicators simultaneously with fixed effects for state and year, linear and quadratic state-specific time trends, individual controls, and SEs clustered by state. State-specific time trends were included to account for trends in potential unobserved confounders and in outcomes that could have related to policy adoption over time. Wald tests confirmed that linear and quadratic

state-specific time trends improved model fit. Individual-level controls include birthing person's age (25–29, 30–34, 35–39, and ≥ 45 years) and health status (categorized as 0, 1, 2, or ≥ 3 comorbidities using the Elixhauser Comorbidity Index⁴⁸). The analysis assumes that missing data for individual variables are rare because the data set was composed of adjudicated billing claims used to determine payments.

A series of sensitivity analyses was also conducted. First, the influence of policy timing was assessed by merging policy data on the basis of birth year rather than on the basis of estimated year of conception ([Appendix Table 2](#)). Second, sensitivity analyses assessed whether including state-level controls, specifically unemployment, poverty, and per capita tobacco consumption rates, and pregnancy-specific alcohol policies⁸ (in separate models) affected findings ([Appendix Tables 3 and 4](#), respectively). Finally, the following adjustments assessed sensitivity to study design decisions: including hours of sale as a continuous (rather than dichotomous) variable ([Appendix Table 5](#)), including only the birthing person's first pregnancy ([Appendix Table 6](#)), including birthing people aged <25 years who could be matched with an infant ([Appendix Table 7](#)), and excluding state-specific time trends from the model ([Appendix Table 8](#)).

Policy and outcome data sets were built in 2021–2022, and analyses were performed in 2023 using Stata, Version 16.1. The University of California San Francisco IRB considered this deidentified data study exempt, and the Penn State IRB did not consider this study human subjects research.

RESULTS

As shown in [Table 1](#), 3.1% of infants in the sample had a morbidity associated with alcohol use during pregnancy, 2.1% had an injury consistent with maltreatment, 6.5% had two or more ED visits, and 2.3% had two or more inpatient admissions. The largest age category of birthing persons was 30–34 years, and most (67.9%) had no comorbidities. As shown in [Table 2](#), the number of states with policies expanding the availability of alcohol increased over the study period, and states varied by when they implemented each policy.

The odds of infant morbidities associated with alcohol use during pregnancy increased when policies allowing liquor sales in gas stations were in effect (AOR=1.39, 95% CI=1.26, 1.53) but decreased when birthing persons lived in states with a government monopoly on retail liquor sales (AOR=0.85, 95% CI=0.82, 0.88) ([Table 3](#)). These findings were generally robust in sensitivity analyses, although gas station sales lost statistical significance in the model including birthing persons aged <25 years

Table 1. Sample Description

Variable	n (%)
Outcomes	
Infant morbidities associated with alcohol use during pregnancy	44,461 (3.1)
Infant injuries consistent with maltreatment	30,157 (2.1)
Two or more infant ED visits	92,586 (6.5)
Two or more infant inpatient admissions	32,345 (2.3)
General population alcohol policies	
Liquor sales allowed in grocery stores	550,042 (38.4)
Liquor sales allowed in gas stations	480,418 (33.5)
Liquor sales allowed on Sunday	1,080,328 (75.4)
Liquor sales allowed after 10PM	980,115 (68.4)
Government monopoly on retail liquor sales	372,728 (26.0)
Age, years	
25–29	417,275 (29.1)
30–34	613,232 (42.8)
35–39	329,046 (23.0)
40–44	68,706 (4.8)
45–50	4,720 (0.3)
Elixhauser comorbidities	
None	972,968 (67.9)
1	326,908 (22.8)
2	95,473 (6.7)
≥3	37,630 (2.6)
Total sample	1,432,979

ED, emergency department.

matched with an infant (Appendix Table 7, available online). In the sensitivity analysis without state-specific time trends, the odds of infant morbidities being associated with alcohol use during pregnancy decreased when

policies allowing liquor sales in gas stations were in effect (AOR=0.65, 95% CI=0.61, 0.69) (Appendix Table 8, available online). In addition, in the main model, the odds of infant morbidities associated with alcohol use during pregnancy decreased when policies allowing liquor sales after 10PM were in effect (AOR=0.88, 95% CI=0.77, 1.00) (Table 3). However, this association lost significance in the majority of sensitivity analyses (Appendix Tables 2–8, available online). Associations between infant morbidities and policies allowing liquor sales in grocery stores and on Sundays were not significant.

The results for infant injuries consistent with maltreatment followed a similar pattern, apart from liquor sales allowed after 10PM. The odds of infant injuries consistent with maltreatment increased when policies allowing liquor sales in gas stations and policies allowing liquor sales after 10PM were in effect (AOR=2.32, 95% CI=1.88, 2.86 and AOR=1.38, 95% CI=1.03, 1.83, respectively) and were reduced when birthing persons lived in states with a government monopoly on retail liquor sales (AOR=0.59, 95% CI=0.54, 0.65) (Table 3). These results were robust, except that allowing liquor sales after 10PM was no longer statistically significant in three sensitivity analyses (Appendix Tables 4, 5, and 8, available online), and living in a state with a government monopoly was no longer significant in one sensitivity analysis (Appendix Table 8, available online). Associations between infant injuries and policies allowing liquor sales in grocery stores and on Sundays were not significant.

Regarding healthcare utilization, allowing liquor sales in gas stations was associated with increased odds of two or more ED visits (AOR=1.18, 95% CI=1.11, 1.25) but was not associated with two or more inpatient admissions (Table 4). Living in states with a government

Table 2. State Alcohol Policy Changes During Study Period

Policy	Number of states with policy from 2005 to 2019 ^a	Policy changes
Liquor sales allowed in grocery stores	19 to 22	Kentucky allowed (2019), Maine allowed (2012), and Ohio allowed (2012)
Liquor sales allowed in gas stations	18 to 18	None
Liquor sales allowed on Sunday	37 to 43	Colorado allowed (2008), Connecticut allowed (2012), Indiana allowed (2006), Tennessee allowed (2017), Texas allowed (2017), Virginia not allowed (2013), Virginia allowed (2016), Washington allowed (2011), Washington not allowed (2013), and Washington allowed (2017)
Liquor sales allowed after 10PM	36 to 40	Texas allowed (2017), Washington allowed (2017), West Virginia allowed (2006), and Wisconsin allowed (2017)
Government monopoly on retail liquor sales	18 to 17	Washington privatized (2012)

^aSample includes people who gave birth between 2006 and 2019, and policies were merged on the estimated year of conception, which includes 2005 in some cases

Table 3. Relationships Between Alcohol Physical Availability Policies and Infant Morbidities and Injuries

Policy	Infant morbidities associated with alcohol use during pregnancy		Infant injuries consistent with maltreatment	
	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Liquor sales allowed in grocery stores	0.93 (0.83, 1.03)	0.16	1.12 (0.91, 1.39)	0.28
Liquor sales allowed in gas stations	1.39 (1.26, 1.53)	<0.01	2.32 (1.88, 2.86)	<0.01
Liquor sales allowed on Sundays	1.08 (0.96, 1.22)	0.22	0.99 (0.79, 1.24)	0.91
Liquor sales allowed after 10PM	0.88 (0.77, 1.00)	0.05	1.38 (1.03, 1.83)	0.03
Government monopoly on liquor retail sales	0.85 (0.82, 0.88)	<0.01	0.59 (0.54, 0.65)	<0.01

Note: Boldface indicates statistical significance ($p < 0.05$ before rounding).

Models include individual-level controls (age, health status), state- and year-fixed effects, state-specific time trends, and account for clustering by state.

monopoly on retail liquor sales was associated with reduced odds for both two or more ED visits and two or more inpatient admissions (AOR=0.94, 95% CI=0.89, 0.99 and AOR=0.95, 95% CI=0.91, 1.00, respectively). Policies allowing liquor sales in grocery stores, on Sunday, or after 10PM were not associated with either two or more ED visits or two or more inpatient admissions.

Results for healthcare utilization were less robust across the range of sensitivity analyses than the primary outcomes. Counterintuitively, government monopoly was associated with increased odds of two or more ED visits in models merged on year of birth rather than conception (AOR=1.10, 95% CI=1.03, 1.17) (Appendix Table 2, available online), and grocery store liquor sales were associated with reduced odds of two or more ED visits in models with state-level control variables (AOR=0.95, 95% CI=0.91, 1.00) (Appendix Table 3, available online). In addition, in models merged on birth year, relationships between gas station liquor sales and two or more ED visits were no longer statistically significant (Appendix Table 2, available online). For two or more inpatient admissions, sensitivity analyses found that gas station liquor sales were associated with increased odds of two or more inpatient admissions in four models (Appendix Tables 4, 6, 7, and 8, available online), whereas government monopoly

lost statistical significance in three models (Appendix Tables 5, 6, and 8, available online). In the sensitivity analysis excluding time trends, government monopoly lost statistical significance for both healthcare utilization outcomes, but other policies gained significance, with the statistically significant associations all indicating that increased alcohol physical availability was associated with increased odds of two or more ED visits or two or more inpatient admissions (Appendix Table 8, available online).

DISCUSSION

This retrospective cohort study examined the relationships between general population alcohol physical availability policies and infant morbidities associated with alcohol use during pregnancy and infant injuries consistent with maltreatment among 1.4 million infant-birthing person pairs. Policies that increase alcohol physical availability were generally associated with worse infant outcomes. Specifically, allowing liquor sales in gas stations was associated with increased odds of both infant morbidities and injuries, whereas living in a state with a government monopoly on retail liquor sales (which decreases availability^{31,33}) was associated with reduced

Table 4. Relationships Between Alcohol Physical Availability Policies and Infant Healthcare Utilization

Policy	Two or more infant ED visits		Two or more infant inpatient admissions	
	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Liquor sales allowed in grocery stores	0.96 (0.91, 1.02)	0.18	0.96 (0.88, 1.05)	0.42
Liquor sales allowed in gas stations	1.18 (1.11, 1.25)	<0.01	0.99 (0.90, 1.09)	0.88
Liquor sales allowed on Sundays	1.01 (0.91, 1.11)	0.90	1.05 (0.86, 1.28)	0.64
Liquor sales allowed after 10PM	1.10 (0.93, 1.30)	0.28	1.07 (0.89, 1.28)	0.48
Government monopoly on liquor retail sales	0.94 (0.89, 0.99)	0.01	0.95 (0.91, 1.00)	0.03

Note: Boldface indicates statistical significance ($p < 0.05$ before rounding).

Models include individual-level controls (age, health status), state- and year-fixed effects, state-specific time trends, and account for clustering by state.

ED, emergency department.

odds of infant morbidities and injuries. Allowing off-premise liquor sales after 10PM was associated with increased odds of infant injuries consistent with maltreatment. Findings for secondary healthcare utilization outcomes were largely consistent with the primary outcomes, although they were less robust.

The findings from this study are generally aligned with previous research on general population alcohol physical availability policies, consumption, and related harms.^{19,20} Privatization—rather than government monopoly control—is associated with increased availability through additional alcohol outlets, longer store hours, and decreased policy enforcement.^{19,31,33,49} Gas stations are an example of an alcohol outlet often in convenient locations with later hours, potentially with reduced stigma around purchasing behaviors. This study finds that privatization and gas station availability were related to increased odds of adverse infant outcomes, which align with results from a recent study of availability policies and drinking among women of reproductive age.⁴⁰ Results from this study also align with the limited research in domestic^{50–52} and international contexts^{38,53} that finds that alcohol availability is relevant for outcomes related to pregnant people's alcohol consumption. Furthermore, this study adds empirical evidence for which general population physical availability policies appear more effective in preventing adverse infant outcomes that are typically the focus of pregnancy-specific alcohol policies.

Findings from this study should be interpreted alongside previous literature examining the impacts of state policies singling out pregnant people's consumption of alcohol. Researchers have found that many of those policies are ineffective and relate to adverse outcomes, including the infant morbidity and infant injury outcomes of this study.^{8–10,54,55} Results from this study suggest that general population alcohol policies rather than those singling out pregnant people may be more effective for reducing adverse infant outcomes related to pregnant people's alcohol consumption.

Although not examined in this study, it is possible that general population policies relate to infant injuries by affecting alcohol consumption among men in the birthing person's family—something to investigate in future research—which has been called for recently by leading alcohol researchers.⁵⁶ This study focuses on outcomes related to pregnant people's alcohol use. However, it is important to note that adverse health consequences of pregnant people's drinking are a small subset of the total adverse public health consequences of alcohol consumption, and there are significant population-level harms related to both men's and women's alcohol consumption across the life course.⁵⁷

Limitations

Several limitations of this study should be acknowledged. First, although most policies changed throughout the study, there were relatively few policy changes, and one policy did not change at all during the study time period (Table 2). Findings should thus be interpreted as associations rather than causal effects. Although it's noted that for the one policy that did not change during the study time period, gas station liquor sales, sensitivity analyses excluding the state-specific time trends showed a change in the direction of the ORs for the relationship between gas station liquor sales and infant morbidities, it did continue to be associated with increased infant injuries and was associated with increased two or more inpatient admissions in sensitivity analyses. Therefore, the specific findings regarding gas station liquor sales and infant morbidities should be interpreted with caution. Second, MarketScan only includes commercially insured individuals, so results may not generalize to populations without commercial insurance. In addition, the data set lacks the necessary measures to adjust for potentially confounding variables (e.g., SES or race), although there is likely less variation in SES given the focus on commercially insured populations. Future research should focus on noncommercially insured, uninsured, and lower SES populations. Third, those aged 12–24 years were excluded from analyses owing to high rates of non-matching of birthing people aged <25 years with infants, which likely reflects insurance patterns for young people, many of whom are still covered under a parent's insurance plan and thus cannot place their infant on the same insurance. One key finding—the association between gas station sales and infant morbidities—lost statistical significance in sensitivity analyses including those aged <25 years who could be matched with an infant. This suggests that future research on how these policies affect outcomes among young pregnant people is needed. Fourth, some groups of infants, specifically infants who entered foster care, may be more likely to have experienced the outcomes under consideration and less likely to have been continuously enrolled in a parent's insurance plan and therefore excluded from the sample. Given the research that suggests that increased alcohol availability relates to longer stays in foster care,⁵⁸ study results may be conservative estimates of the impacts of these policies. Future research that can track infant outcomes across payors would help to ensure more precise estimates. Fifth, although a rigorous approach was used to measure infant morbidities associated with alcohol use during pregnancy and infant injuries consistent with maltreatment—an approach that overcomes several challenges measuring fetal alcohol spectrum disorders across states and over time⁵⁹—these variables are based

on insurance claims data. These outcome measures, such as all outcomes in health services research, are imperfect measures of the underlying phenomenon and should not be interpreted as precise prevalence.

CONCLUSIONS

Results show that state-level general population policies that expand the physical availability of alcohol were generally associated with increased odds of infant morbidities and injuries. Although state policy trends over the last few decades have increased the availability of alcohol, findings from this study suggest that a reverse in this trend—limiting alcohol availability—may help reduce adverse infant outcomes related to pregnant people's alcohol consumption.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2024.01.003>.

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